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The Study on Daily Combined Activities of Regular Medical Treatment and Shopping for People Who Live in Depopulated Area

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Abstract

There are many removed, depopulated aging areas in Japan, including isolated islands. Habitants are usually under poor transportation condition. One of the way to solve this problem is to improve the transportation service. Under this poor situation, it often seems that habitants combine two or three activities in a day. The purpose of this study is to know how people choose their activities, depending on given transportation service. This study pick up two activities of regular medical treatment and shopping that are main purpose of daily trip for elderly person in these place, and made a model for people's behavior when choosing their activity time and activity pattern. Then, we calibrated this model to observed depopulated place, and got a good fitness.

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Keywords: depopulated area; aging person; regular medical treatment trip; shopping trip; public transportation; isolated island

1. Introduction

Recently, Japan is becoming aging society. Some areas are being depopulated, including isolated islands around Japan. Many of these areas are almost far from urban cities. Because of the lack of inadequate transportation system, they have poor environment on activities for living such as shopping or

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recreation. To solve this problem, improving the transportation service could be available. Life activities include many kind of one. This study focuses on two activities; regular medical treatment and shopping. Because these two activities are becoming necessary main purpose of daily trip for elderly person in such depopulated, aging place. Under poor transportation environment, the habitants who live in the depopulated place have fewer occasions for trip than people under rich one. So, they could tend to combine two or three trip purposes in one day trip. The purpose of this study is to know how long or frequent people spent their time for these activities, choosing to do single activity or combined activities, responding to the level of improved transportation service. For this purpose, we made a model for estimating Utility/Disutility of people when choosing their activity time. Then, we calibrated this model to observed depopulated place.

The model that we are proposing is the kind of choice model. One of the typical choice models is logit model that uses the random utility theory (McFadden, D. (1978), Ben-Akiva, (1985)). Our model is to express the choice of activity time. Abkowitz, (1981), Bhat, (1998a) , (1998b) and McCafferty, (1982) used logit model to predict activity time. But, those models are treated time as discrete variables. In the context of the continuous method utilized in order to relieve the limitation of the discrete method, Ramli,(2010a), (2010b) (2011) proposed a model that used marginal utility or disutility of primary factors related to the points of time during one day of shopping travel, such as departure time, arrival time, stay time and travel time. In this paper, we propose a model, improving the model that Ramli,(2010a), (2010b) (2011) made.

2. Model

The model is made up of two parts, time decision model and trip pattern choice model. Time decision model represents the decision of departure time at origin place (usually home), arrival time and leave time at destination place, arrival time at origin place, and so on. Trip pattern choice model represents the choice of one trip in a day or combined trips in a day when people have some necessary trip purposes like shopping and commuting .For necessary trip purpose, we pick up two trip purposes, regular medical treatment trip and shopping trip. For habitants who live in removed depopulated area or isolated island, because of the lack of merchandise and medical service, those two activities to mainland or major city are necessary ones in their lives. The research that mentioned later also shows a lot of these types of activities.

We define two patterns. The first is that people go for regular medical treatment trip or go for ordinary shopping on different days. The second is that people do two activities in the same day. Habitants in depopulated place chose any of two patterns and decide their activity time ,such as departure time, back home time, considering given transportation services. Then, we assume that people decides their activity time to minimize the disutility. We define some disutility functions as following.

(1) Disutility of Shortness on shopping time: D_1

$$\mathrm{D}_1(t_s) = \mathrm{m}\exp(-\alpha t_s) \tag{1}$$

(2) Disutility of lateness on shopping time : D_2

$$\mathrm{D}_2(t_k) = \mathrm{B}(t_k - t_b) \tag{2}$$

(3) Disutility of longness on shopping time : D_3

$$\mathrm{D}_3(t_s) = \delta t_s \tag{3}$$

(4) Resistance to movement: D_4

$$\mathrm{D}_4(t_n, C) = \gamma_1 \mathrm{t_n} - \gamma_2 \mathrm{C} \tag{4}$$

where t_{in} , t_s , and t_o are arrival time, a stay time, and leave time at a shopping place respectively.

t_{om} is desirable leave time. t_h is arrival time at home. t_b is threshold time that people can't perceive disutility D_2， $m, \alpha, B, \delta, \gamma_1, \gamma_2$ are positive parameters， t_n, *and* C are time and cost when people move. $\boldsymbol{t_s}$

can be defined t_s=t_o-t_{in} and t_h also can be defined t_h=t_o+t_n. So, equation (1), (2), (3) can be represented by t_{in}, t_n and t_o.

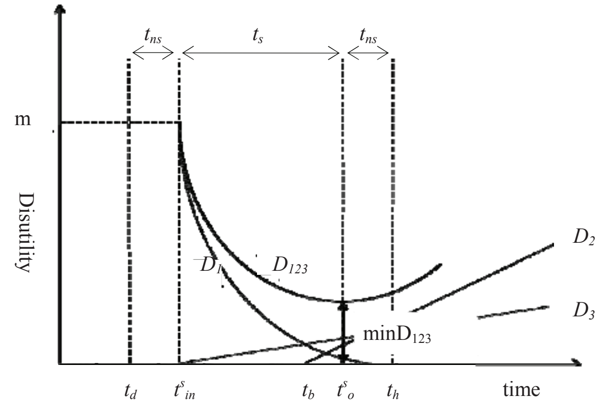

Fig.1. Illustration of pattern 1 (only going shopping)

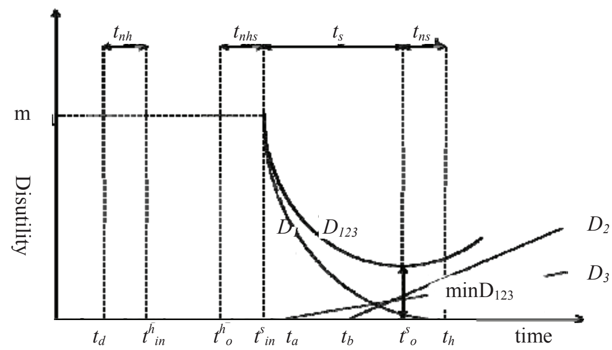

Fig.2. Illustration of pattern 2 (going both shopping and for regular medical treatment)

Figures 1 and 2 show the illustrations that explain the decision of the desirable leave time t_{om} (= t^s_o in figures) for each pattern, using these disutility functions. Fig. 1 shows the pattern that people only go shopping on a day. Fig. 2 shows the one that people do both shopping and regular medical treatment in a day. In these figures, t_d, t_h stands for departure time, arrival time at home (origin). A subscription *h* stands for "regular medical treatment (hospital)", a subscription *s* stands for "going to shopping". t_{ns}, t_{nh} are travel times from home to shopping place, hospital respectively. t_{nhs} mean travel time from hospital to shopping place. t^s_{in} is arrival time at shopping place. In Fig. 2, t^h_{in}!and!t^h_o stand for arrival time, leave time at hospital.

People decide their leave time (shopping end time) t_{om} (= t^s_o in figures) to minimize the total disutility D_{123} that are summed up D_1, D_2 and D_3. In the case of regular medical treatment, people can't decide the treatment time by themselves because this time is usually decided by a doctor. That's why arrival time t^h_{in} at hospital and departure time t^h_o at hospital to next destination or origin are given as input (initial) conditions in this model. The total disutility for pattern 1 is the sum of the disutility D_{123} and the disutility of regular medical treatment on another day. In this case, the disutility for regular medical treatment represent the travel time and cost.

In this paper, we assume that the above activities are restricted by lunch, so we introduce a start time at lunch t_{ls} and duration of lunch time t_{lc} to the model, and then people take the uniform disutility D_{lunch} in this term.

People compare the total disutility of D^1 for pattern 1 with D^2 for pattern 2, and they chose the smaller one and decide their pattern.

The optimal activity end time t_{om} is different to each person, so we define parameter α as lognormal distribution, parameter t_{ls} and t_{lc} as normal distribution. These distributions in this model are defined as individual difference. The dispersion of the activity start time t_{in} is represented by provability density function $\varphi_{\mathrm{tin}}(t_{in})$. These are independent on each other. The distribution of the optimal end (leave) time t_{om} is estimated, using initial conditions, α, t_b, t_{ls} and t_{lc}, and doing change of variables to the arrival time t_{in}. The provability function of t_{om} represents to follow.

$$\varphi_{\mathrm{tom}}(t_{om}) = \iiiint \varphi_\alpha(\alpha) \left| \frac{d\alpha}{dt_{om}} \right|_{tin,tb,tls,tlc} \varphi_{ttn}(t_{in}) \varphi_{tb}(t_b) \varphi_{tls}(t_{ls}) dt_{in} dt_b dt_{is} dt_{lc} \tag{5}$$

An individual do different activities under the same situation. To consider this occasional difference, we introduce provability error term ε_1, ε_2 in pattern 1, pattern 2 respectively. we here define $\varepsilon=\varepsilon_1=\varepsilon_2$. The two total disutility of pattern 1 and 2 are represented by $D_{p1}=D^1+\varepsilon_1$, $D_{p2}=D^2+\varepsilon_2$, each provability density functions are represented by $\Phi_{Dp1}(D \mid t^s_{in})$ and $\Phi_{Dp2}(D \mid t^s_{in})$. The provability P_{p2} that one selects pattern 2 is calculated by follow.

$$P_{p2}(t^s_{in}) = \int_{-\infty}^{\infty} \Phi_{Dp1}(D | t^s_{in}) \int_{-\infty}^{D} \Phi_{Dp2}(e | t^s_{in}) \, de dD \tag{6}$$

3. Application of the model

For applying the model to two patterns of activities, we chose Oshima island located in Fukuoka prefecture, and conducted an inquiry research about outside activities for habitants for two weeks, from July to August, 2009. Oshima island is 13 km away from Munakata city. The population is about 780. Aging rate is about 41%. There are a few small shopping place and a small medical clinic. The habitants often go to Munakata city for shopping, recreation and other trip purposes, using ferry boat for 20 minutes to the port of Kounominato. We inquired age, family size, trip purpose, departure time, destination, transportation and arrival time. In applying the propose model, we also used the data that had taken place in Munakata city, Fukuoka prefecture, from Jun. to Feb., 2008.

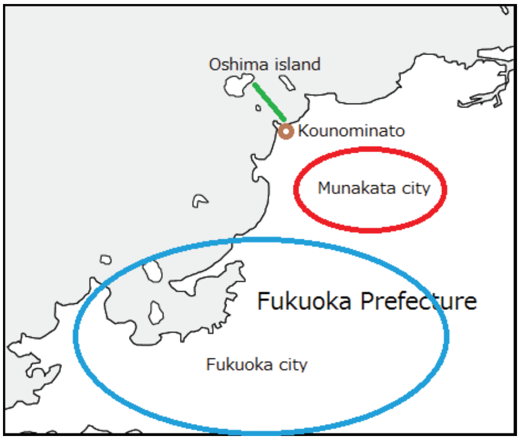

Fig. 3. Oshima island and Munakata city in Fukuoka prefecture

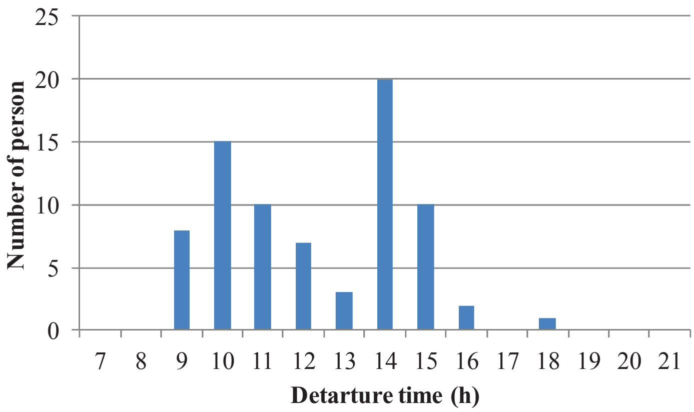

Fig. 4. Departure time at hospital

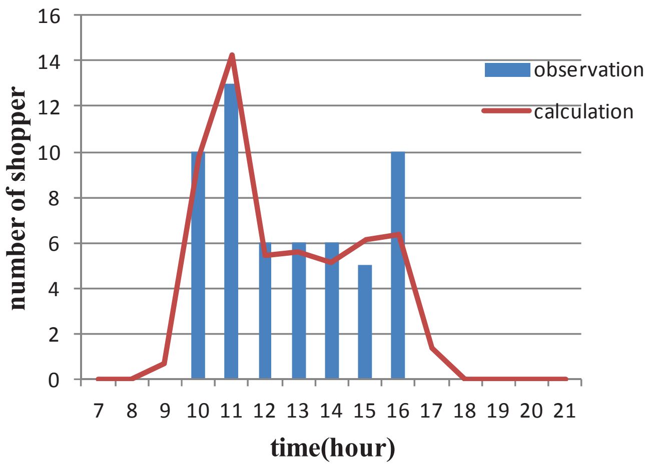

Fig. 5. Distribution of leave time at shopping place in observation and calculation on pattern 1

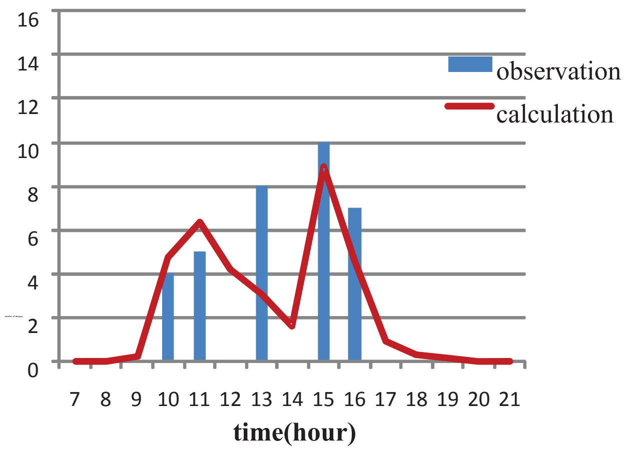

Fig. 6. Distribution of leave time at shopping place in observation and calculation on pattern 2

Table 1. The observation number and the calculation number for pattern 1 and 2.

	Observation	Calculation
pattern 1	56	54.8
pattern 2	34	35.2

Table 2. The result of parameter's calibration

Squared	m	$\alpha(\mu)$	$\alpha(\sigma)$	γ_1	γ_2	$\varepsilon(\sigma)$
74	1	2.48	0.61	1.4	0.004	1.81

Table 3. The value of cited parameters

B	$tb(\mu)$	$tb(s)$	d	$tls(\mu)$	$tls(\sigma)$	$tlc(\mu)$	$tlc(\sigma)$	D
0.03	18.25	0.46	0.02	12.29	1.03	2.79	0.61	0.93

The result of applying the model to these data is shown in table 1 that shows both the observation and the calculation number for each pattern. Fig. 5 and 6 show the observed and calculated distribution of leave time t^s_o on pattern 1, 2 respectively. Fig. 4 shows the distribution of departure time at hospital t^h_o as initial condition.

We conducted K-S test under assumption that distribution of calculated leave time for shopping equals to the one of observation time (Figs. 1 and 2). The results were significant in significance level 20%. The parameters required from this estimation are shown in Table 2. Some of these parameters were cited from Oeda, Y. (2009). These parameters are shown in Table 3. It is found that parameter γ_1 related to travel time is bigger than others, therefore, travel time is effective factor in this model.

4. Conclusions

In this paper, we proposed the model of activity time decision and the model of activity choice, and apply them to outside activity on shopping and regular medical treatment for people who live in island close to mainland that have some major cities. In this models, we treated two activities as one day activity or as two days activities. We calibrated these model's parameters, using search data in Oshima island and Munakata city in Fukuoka prefecture. We compared estimation for the rate of choice of two pattern and leave time at shopping place with observation's. We confirmed that the result is proper. But, despite there are a lot of outside activities, we neglect them in this study. In the future, we have to make up proposed model adding these activities.

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